

Construction and Design of Cable-Stayed Bridges

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I. INTRODUCTION

Cable-stayed bridges are constructed along a structural system which comprises an orthotropic deck and continuous girders which are supported by stays, i.e. inclined cables passing over or attached to towers located at the main piers. The idea of using cables to support bridge spans is by no means new, and a number of examples of this type of construction were recorded a long time ago. Unfortunately, the system in general met with little success, due to the fact that the statics were not fully understood and that unsuitable materials such as bars and chains were used to form the inclined supports or stays. Stays made in this manner could not be fully tensioned and in a slack condition allowed large deformations of the deck before they could participate in taking the tensile loads for which they were intended.

Wide and successful application of cable-stayed systems was realized only recently, with the introduction of high-strength steels, orthotropic type decks, development of welding techniques and progress in structural analysis. The development and application of electronic computers opened up new and practically unlimited possibilities for the exact solution of these highly statically indeterminate systems and for precise static analysis of their three-dimensional performance.

Existing cable-stayed bridges provide useful data regarding design, fabrication, erection and maintenance of the new system. With the construction of these bridges many basic problems encountered in their engineering are shown to have been successfully solved. However, these important data have apparently never before been systematically presented. In summary, the following factors helped make the successful development of cable-stayed bridges possible:

- 1) The development of methods of structural analysis of highly statically indeterminate structures and application of electronic computers.
- 2) The development of orthotropic steel decks.
- 3) Experience with previously built bridges containing basic elements of cable-stayed bridges.
- 4) Application of high-strength steels, new methods of fabrication and erection.
- 5) The ability to analyse such structures through model studies.

II. LITERATURE REVIEW

Wei-Xin Ren (1999), presented “*Ultimate behaviour of long span cable-stayed bridges*”. The study described here investigates the nonlinear static and ultimate behaviour of a long-span cable-stayed bridge up to failure and evaluates the overall safety of the bridge. Both geometric and material nonlinearities were involved in the analysis.

Jin Cheng, Jian-Jing-Jiang, Ru-Cheng Xiao and Hai-Fan Xiang (2002), proposed “*Advanced aerostatic stability analysis of cable-stayed bridges using finite-element method*” which was based on the concept of limit point instability, an advanced nonlinear finite-element method was used.

Paolo Clemente, Mehmet Çelebi, Giovanni Bongiovanni and Dario Rinaldis (2004), proposed “*Seismic analysis of the Indiano cable-stayed bridge*”. This paper presents results of observed and analytical analysis of the dynamic response of the Indiano Cable-Stayed Bridge in Florence, Italy. The observed part was based on ambient and traffic-induced vibration tests, which allowed extracting the dynamic characteristics of the structure in terms of resonance frequencies, modal shapes and damping.

Shuqing Wang and Fu (2006), presented “*Static and stability analysis of long-span cable-stayed steel bridges*”. The analysis based on an ideal state as well as the simulation and controls to reach it are common issues in the design and construction of a cable-stayed bridge. For a long-span cable-stayed bridge, the huge initial stress accumulated in the pylon and the girder will reduce the overall structure stiffness.

Krzysztof Zoltowski and Tomasz Wask (2008), presented “*Dynamic analysis and site test of Cable-stayed bridge over Vistula river in Plock*”. The advanced FEM model was developed to verify the structure. Static and dynamic site test was executed to study mechanic nature of the structure. Dynamic load was implemented to the deck and response of superstructure was measured. On the basis of advanced FEM model and site test results, the dynamic response of spans and cables under the traffic load was developed.

III. MATERIAL AND METHODOLOGY

MIDAS/Civil enables us to readily create nodes and elements as if we were drawing drawings using the majority of functions used in CAD programs.

The following two methods are mainly used for generating elements in **MIDAS/Civil**:

- ✚ Enter the nodes first and then enter the elements using these nodes.
- ✚ Enter the nodes and elements simultaneously using the predetermined grids.

The second method is generally recommended for expediency. Grids are generated first. The presence of the grids significantly reduces the risk of making mistakes during the modelling. This is highly efficient as nodes and elements are created at the same time.

The first method is used when the geometric arrangement of elements is so irregular that the application of grids is not expected to offer any advantage. This method is used to perform a partial, detail analysis of planar elements.

The grids are laid out in the x-y plane of the UCS. The procedure to layout the Point Grids is simple enough since the grid spacing is regular in each direction of the axes, but unsuitable for modelling an irregularly spaced structure. In such a case, the use of Line Grids is more effective.

During the modelling task, because various functions are alternately used to create nodes and elements, it is convenient to use Model Entity Tab at the top of the dialog bar located on the left of the screen. The desired function in the function list can be selected or the Toolbars on the right of the working window can be used rather than using the Main Menu.

The distance, coordinate, directional vector or node number can be directly typed on the keyboard in the dialog bar. Alternatively, the relevant distance or position can be conveniently assigned in the Model Window with the mouse cursor. When the mouse cursor is used to enter the above entities, click the relevant data field once and the background colour of the data field will change to pale green. Then, enter the relevant data in the Model Window (Mouse Editor Function).

IV. APPLICATION AREA

Reinforced Concrete Bridge: Slab Br., Frame Br., PSC Beam Br

Composite Structural Steel Br.: Box/Plate Girder Br., Steel Deck Br

PSC Box Bridge: FCM, ILM, MSS, FSM, PSM

Long Span Bridge: Suspension, Cable Stayed & Arch Bridges

Heat of Hydration for Mass Conc.: PSC Box Br., Abutment, Pier, Breakwater

Underground Structures: Tunnel, Subway, Municipal service facilities

Plant Structures: Tank, Pressure vessel, Transmission tower, Power plant

Public facilities: Airport, Dam, Harbor

V. CONCLUSION

MIDAS Civil is a state of art software, which defines a new paradigm for engineering and civil

structures. It provides a distinctively easy user interface through its innovative graphics modules. Midas Civil provides an optimal design solution, which analyzes and designs all types of bridge structures in 3-D environments accounting for construction stages and time dependent properties. Combining structural analysis capabilities with civil engineering specific stage analysis, pushover analysis and nonlinear time history features, MIDAS Civil provides the necessary tools for advanced modeling, analysis and design for the bridge engineer. Features include RC, steel, PSC bridge design, suspension and cable-stayed bridge analysis, construction analysis and heat of hydration analysis, just to name a few.

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